Department of Food and Agriculture
Information on Rice Pesticides
Submitted to the Central Valley Regional Water Quality Control Board
January 22,1991

Programs were implemented since 1983 to reduce discharges of the rice herbicides molinate (Ordram®) and thiobencarb (Bolero®). In 1990, the objectives of these control efforts were clarified, following the adoption of amendments to the Central Valley Regional Water Quality Control Board's (Regional Board's) water quality control plan. This plan established performance goals for molinate and thiobencarb, beginning in 1990, and for the insecticides carbofuran (Furadan®), methyl parathion, and malathion, beginning in 1991.

The information provided below reviews the factors affecting quantities of molinate and thiobencarb discharged to drains and efforts to meet 1990 performance goals. A summary of pertinent monitoring efforts is also provided. Programs are proposed which will reduce discharges of molinate, thiobencarb, carbofuran, methyl parathion, and malathion to levels which comply with 1991 performance goals.

CONDITIONS IN 1990

PROGRAM DESCRIPTION

Programs developed to control the discharges of molinate and thiobencarb into state waters were implemented using restricted materials permits conditioned to mitigate water quality problems associated with the use of these pesticides. The conditions, as required by the department, are presented below.

Molinate

1. All water treated with products containing molinate must be retained on the treated acreage for at least 19 days following application unless:

a. the treated water is contained within a tailwater recovery system, ponded on fallow land, or contained in other systems appropriate for preventing discharge.

   1. If the system contains discharges from the property of a single permit holder, treated water may be discharged from the treated field after compliance with product labeling. The system may discharge after 19 days following the last application of molinate within the system.

   2. Systems that contain discharges from the property of two or more permit holders, treated water may be discharged from the treated field after 8 days following application. The system may discharge after 12 days following the last application of molinate within the system.

b. the treated water is on acreage within the bounds of specific geographic areas that discharge negligible amounts of rice field drainage into the Sacramento River or its tributaries until fields are drained

for harvest. All water on fields treated with molinate must be retained on the treated acreage for at least 8 days following application.

2. Fields not specified in 1.a. and 1.b. may resume discharging field water after the 19 day retention period at a volume not to exceed two inches of water over a drain box weir. Unregulated discharges from these fields may then resume after 7 days.

3. The County Agricultural Commissioner may authorize the emergency release of tailwater after 6 days following application after reviewing a written request which clearly demonstrates that the crop is suffering because of the water management requirements. Under an emergency release variance, tailwater may be released only to the extent necessary to mitigate the documented problem.

Thiobencarb

1. All water treated with products containing thiobencarb north of the line defined by Roads E10 and 116 in Yolo County and the American River in Sacramento County must be retained on the treated fields for at least 30 days following application unless:

a. the treated water is contained in a tailwater recovery system, ponded on fallow land, or contained in other systems appropriate for preventing discharge. Water may be discharged from treated fields within these systems after 6 days following application.

    1. If the system contains discharges from the property of a single permit holder, treated water may be discharged from the system after 19 days following the last application of thiobencarb within the system.

    2. If the system contains discharges from the property of two or more permit holders, treated water may be discharged from the system after 14 days following the last application of thiobencarb within the system.

b. the treated water is on acreage within the bounds of specific geographic areas that discharge negligible amounts of rice field drainage into the Sacramento River or its tributaries until fields are drained for harvest. All water on fields treated with thiobencarb must be retained on the treated acreage for at least 6 days following application.

2. All water treated with products containing thiobencarb south of the line defined by Roads E10 and 116 in Yolo County and the American River in Sacramento County must be retained on the treated fields for at least 6 days following application.

Valent Chemical Company, distributor of products which contain thiobencarb, agreed to limit the distribution of thiobencarb for use on properties described in 1. above to 4.4 million pounds or enough to treat 110,000 acres. An additional 440,000 pounds could have been used if, on May 1, 1990, flows in the Sacramento River at the "I" Street Bridge in Sacramento

1990, flows in the Sacramento River at the "I" Street Bridge in Sacramento were forecast to exceed 15,000 cubic feet per second.

Discussion

The Department of Food and Agriculture (CDFA) implemented the programs through county agricultural commissioners. Pesticide use permits issued for the use of molinate and thiobencarb included permit conditions with the requirements presented above. Compliance with permit conditions was also enforced by the commissioners.

The molinate program retains the basic strategies of earlier programs, but in 1990 the water holding requirement for most molinate users increased by five days over the requirement used in 1989. The half-life of molinate in treated rice field water is usually three to four days, so this new requirement should have been able to reduce peak concentrations of molinate in water discharged by individual growers by at least 50%. A reduction of this magnitude would have helped meet the 1990 performance goal for molinate of 30 parts per billion (ppb). The program allowed multi-user recirculating systems to be managed as they were in 1989. Discharges from these systems could not occur for at least twelve days following the last application within the system. Because applications occur over a period of weeks, the majority of the molinate applied within the system was retained much longer than the twelve day minimum.

The thiobencarb program also retained the basic structure of the 1989 program. Strict water management requirements and a sales limit in the Sacramento Valley of 4.4 million pounds of formulated product was thought to be adequate to meet the 1990 performance goal for thiobencarb. In addition, the popularity of the herbicide bensulfuron methyl (Londax®) in recent years has had the effect of making thiobencarb a minor use herbicide. In 1990, treated water retained in a system that services the property of only one thiobencarb user had to be held for 19 days following the last application within the system, compared to 14 days in 1989. Discharges into and out of large recirculating systems and closed districts were be managed as in 1989.

Carbofuran

Granular carbofuran was, by requirment, incorporated into the top layer of soil of the uppermost two checks of each field. This satisfactorily protected waterfowl which forage in rice fields as the fields are flooded. No programs were in place in 1990 to prevent discharges of carbofuran into state waterways.

Methyl parathion

Label instructions on product containing methyl parathion and registered for use on rice required no treated water be released for three days following application. Aside from these instructions, no programs were in place in 1990 to prevent discharges of methyl parathion into state waterways.

Use of Selected Pesticides in 1990

In the nine rice-growing counties in the Sacramento Valley, county agricultural commissioners record the acreage treated with molinate and

thiobencarb when Notices-of-Application are submitted to each county office. Based on these records, it was estimated that 370,260.5 acres were treated with molinate and 23,603 with thiobencarb (Table 1). Molinate use was 6.6% higher than in 1988, but 1.5% lower than in 1989. Thiobencarb use, responding to the advent of the new rice herbicide, bensulfuron methyl, was 76.6% lower than in 1988 and 39.3% lower than in 1989.

Uses of carbofuran, methyl parathion, and malathion can only be quantified through the Department's pesticide use reporting program. This program greatly improves the department's ability to characterize, temporally and spatially, pesticide applications made in the state. The program is in its first year of implementation and data entry is behind schedule; use report data for carbofuran, methyl parathion, and malathion collected since March, 1990 are not yet available.

County Agricultural Commissioners and Enforcement Activities

The agricultural commissioners in the nine Sacramento Valley rice growing counties are responsible for the enforcement of the rice pesticide programs. The role of the commissioners and their staffs include explaining the program to growers, pest control advisers and operators; issuing permits for use; making field inspections for compliance; approving emergency release variances; and providing CDFA with information on the use of pesticides.

Before any material on the list of California restricted materials may be applied, growers must obtain a permit from their county agricultural commissioner. The permits may specify conditions for use of the material, including post-application water holding requirments. A Notice of Intent (NOI) is required 24 hours prior to the application, providing the commissioners with the option to observe the mixing, loading, and application of the material and to thus enforce regulations which pertain to pest control operations. Molinate, thiobencarb, carbofuran, and methyl parathion are currently California restricted materials; malathion is not. Permits which specify post-application water holding requirments, like those for the use of molinate and thiobencarb, also require that the Notice of Application (NOA) be filed within 24 hours after the application.

County agricultural commissioners had the ability to grant variances on the holding requirements for fields treated with molinate or thiobencarb if the length of the holding time was adversely affecting the rice plants. Field water was only drained to the extent necessary to restore a healthy growing environment for the rice seedlings.

The number of acres in each county in the Sacramento Valley that were involved in the emergency release variances are presented in Table 2. County agricultural commissioners granted variances for 23,394 of the 370,261 acres treated with molinate. Most of those acreages were lowered only a few inches in order to correct problems caused by deep water and cool temperatures associated with heavy rain in late May.

Federal ASCS Program

Federal funds were available again in 1990 through the Agricultural Stabilization and Conservation Service (ASCS) for the installation of tailwater recovery systems servicing rice-growing acreages. Grants of up

to $3,500 were available for qualified individuals and up to $10,000 for a number of growers operating under a pooled agreement. The USDA - Soil Conservation Service provided engineering support for the design and construction of these systems.

Federal grants totaling $901,127 were distributed to 160 applicants since the funds became available in August 1986, and contributed over half of the total cost of the tailwater recovery systems Table 3.

Cooperative Monitoring Program

Summaries of the monitoring activities addressing molinate, thiobencarb, bensulfuron methyl, carbofuran, methyl parathion, and malathion in the Sacramento Valley in 1990 are presented here. Abbreviations for locations of monitoring sites referenced in this report can be interpreted as follows:

CBD1	Colusa Basin Drain at Roads 109 and 99E near Knight's Landing in Yolo County, near its outfall on the Sacramento River,
CBD5	Colusa Basin Drain at Highway 20 in Colusa County,
BS1	Butte Slough at Highway 20 in Sutter County,
SS1	Sacramento Slough at the Department of Water Resources gauge station in Sutter County, near its outfall on the Sacramento River,
SRRUN4	Sacramento River, approximately 3 km downstream from confluence with Colusa Basin Drain, midchannel,
SR1	Sacramento River at Village Marina, approximately 1.5 km upstream from confluence with American River, in Sacramento County,
SR2	Sacramento River at Freeport Bridge in Sacramento County,
SR4	Sacramento River at Rio Vista in Sacramento County,
SRRAW	Sacramento River at the intake to the water treatment facility in Sacramento, approximately 0.3 km downstream from confluence with American River, in Sacramento County.

Molinate and thiobencarb - The molinate and thiobencarb monitoring program in the Sacramento Valley, consisted of weekly samples collected from the agricultural drains and the Sacramento River from late-April through June by the Department of Fish and Game (DFG). During the period when the highest concentrations were expected (mid-May to mid-June), an additional sample was collected each week. Samples were delivered to ICI Americas Inc. (formerly Stauffer Chemical Company) for molinate and thiobencarb analyses. Split samples representing about 20% of the total collected were analyzed by the DFG laboratory for the presence of both compounds.

The City of Sacramento analyzed water samples collected from the Sacramento River at the intake to its water treatment plant from April 18 through June 25. Daily samples were collected from May 21 through June 13.

Bensulfuron methyl - DFG collected water samples from CBD1, SS1, and SR1 twice each week from May 21 through June 21. Samples were analyzed by Morse Laboratories in Sacramento under contract with E. I. du Pont de Nemours and Company.

The City of Sacramento monitored water from its intake on the Sacramento River for bensulfuron methyl on May 30.

Carbofuran - Samples were collected by DFG from the Colusa Basin Drain at CBD1 and CBD5, Sacramento Slough (SS1), and Sacramento River (SR1) twice weekly from April 16 through June 25. Analyses were performed by FMC Corporation who markets carbofuran under the trade name Furadan®. About 20% of the samples were split with DFG, whose laboratory analyzed the samples for quality assurance.

Methyl parathion and malathion - Samples were collected by DFG from the Colusa Basin Drain at CBD1 and the Sacramento River (SR4) approximately three times weekly from April 11 through June 25. At Sacramento Slough (SS1), samples were collected once each week from April 16 through April 30, then approximately twice weekly from May 7 through June 25. Analyses were performed by DFG.

Results of Monitoring Program

Molinate - The results of analyses performed by ICI Americas Inc. on samples collected by DFG from major agricultural drains and the Sacramento River as part of the main component of the molinate monitoring program are presented in Table 4. The highest concentrations of molinate in the agricultural drains of the Sacramento Valley occurred in the Colusa Basin Drain in Colusa County (CBD5) where 59 ppb were detected in samples collected on May 31. Peak concentrations detected at CBD1 and SS1 were 51 ppb and 40 ppb, respectively. Figure 1 illustrates peak concentrations of molinate at CBD1 in the years 1981 - 1990, compared to the established molinate performance goals. The 1990 performance goal for molinate was exceeded at each monitoring site located in agricultural drains.

The highest concentration of molinate detected in the Sacramento River was 8.9 ppb, detected in a sample collected from SR1 on June 4. Molinate concentrations detected by the City of Sacramento at the intake to its water treatment facility on the Sacramento River are presented in Table 5. Concentrations peaked on June 4 when 6.5 ppb were detected, a 44% increase obove the peak concentration detected there in 1989.

Thiobencarb - Concentrations of thiobencarb in samples collected from the agricultural drains and the Sacramento River are presented in Table 6. Maximum thiobencarb concentration in the major agricultural drains was 2.0 ppb in Butte Slough (BS1) on May 28. The peak concentration of thiobencarb in an agricultural drain in 1989 was 1.34 ppb at CBD1 on June 15. Figure 2 illustrates peak concentrations of thiobencarb at CBD1 in the years 1981 - 1990, compared to the established thiobencarb performance goals. Concentrations in samples collected from the Sacramento River at SRRUN4 and SR1 were less than the 0.5 ppb detection limit.

The highest concentration of thiobencarb detected in the Sacramento River at the City of Sacramento water treatment plant was 0.52 ppb on May 30 (Table 5).

Bensulfuron methyl - Concentrations of bensulfuron methyl detected in the Colusa Basin Drain and Sacramento Slough near their outfalls on the Sacramento River and in the Sacramento River immediately upstream of the

American River are presented in Table 7. The highest concentration detected in an agricultural drain was 2.10 ppb, detected at CBD1 on June 10. Nobensulfuron methyl was detected in the Sacramento River at SR1 or at the intake to Sacramento's water treatment facility.

Carbofuran - Results of analyses performed by FMC Corporation are presented in Table 8. The peak concentration of carbofuran observed in this survey was 2.6 ppb, detected in a water sample taken from the Colusa Basin Drain at CBD1 on April 30. The peak concentration at CBD1 was 1.1 ppb, which represents the mean of two analyses performed on a sample collected on May 3. Concentrations of carbofuran at CBD1 in the years 1987 through 1990 are compared to carbofuran performance goals in Fig. 3. Carbofuran was detected in a sample taken from the Sacramento River at SR1 on April 16. Because carbofuran was not concurrently detected in the agricultural drains which service rice growing regions, this detection may be questionable.

Methyl parathion - Concentrations of methyl parathion in the Colusa Basin Drain at CBD1, Sacramento Slough at SS1 and in the Sacramento River at SR4 are presented in Table 9. The highest concentration of methyl parathion in this survey was 0.66 ppb, detected at CBD1 on May 17. Concentrations there exceeded the 1991 performance goal for methyl parathion for almost two weeks. Methyl parathion was detected in the Sacramento Slough on June 4, when 0.10 ppb was present, but none was detected in the Sacramento River at SR4.

Malathion - Malathion concentrations at CBD1, SS1, and SR4 are also presented in Table 9. Malathion was only detected at CBD1, where 0.59, 0.12, and 0.15 ppb were present on May 24, June 2 and June 4, respectively.

Mass Transport in the Sacramento River

The total mass of molinate and thiobencarb transported in the Sacramento River past Sacramento may be used to compare the pesticide load in different years. Mass transport cannot be used to determine compliance with performance goals.

The mass transport of molinate and thiobencarb in the Sacramento River were estimated for the years 1982 - 1990. These estimates were calculated using concentrations of contaminants in the river at SRRAW as measured by the City of Sacramento and the average daily flows of the Sacramento River at the Freeport. The measured concentrations were corrected in an attempt to more accurately represent average daily concentrations. This step helps address the effects of tides on the mixing dynamics of the American and Sacramento Rivers. Yearly totals of mass transport of molinate and thiobencarb can be expressed as the following:

$$\sum \left(\text{conc} \times \frac{SR_t}{SR_o} \times \text{flow}_{SR} \times K \right)$$

where conc = concentration of contaminant detected daily by the City of Sacramento in the Sacramento River at the intake to their water treatment facility in ppb (i.e. µg/l);

SR_t = the theoretical average daily percentage of Sacramento River water at the intake to the water treatment facility at Sacramento

that had its origins in the Sacramento River upstream of the confluence of the American River, based on average daily releases from Nimbus Dam on the American River and average daily flows in the Sacramento River at Freeport;
SR_o = the observed percentage of Sacramento River water at the intake to the water treatment facility at Sacramento that had its origins in the Sacramento River upstream of the confluence of the American River at the time the water sample was taken for determination of pesticide concentration, based on results of daily comparative analysis of conductivity performed on water samples drawn from the Sacramento and American Rivers;
$flow_{SR}$ = average daily flow, measured in cubic feet per second, of the Sacramento River at Freeport; and
K = a conversion factor (28.33 L/ft^3 × 60 sec/min × 60 min/hr × 24 hr/day × 1 $kg/10^9 \mu g$).

Concentrations less than the detection limit of 0.1 ppb were regarded as zero. For the few dates when analytical data were not available, linear interpolation was performed to estimate the missing data.

The estimated mass transport of molinate and thiobencarb in the Sacramento River past Sacramento during 1982 through 1990 is presented in Table 10. The mass transport of molinate in 1990 was estimated to be 2,858 kg (6,288 lbs), an increase of 43% from 1989 totals and a 85% reduction since 1982. The 51.4 kg (113.8 lbs) of thiobencarb transported in the river in 1990 represents a 352% increase from the 11.4 kg (25.2 lbs) transported in 1989.

Weather and Its Influence on Water Quality

Weather conditions during May, 1990 were unfavorable for the dissipation of molinate and thiobencarb and for the minimization of their presence in agricultural drains and the Sacramento River. The application season in May was accompanied by low air temperatures, cloudy skies and unseasonably heavy rain (Fig. 5). The volatilization rates of both molinate and thiobencarb are relatively low under such conditions. In addition, the rain made it difficult for growers to maintain water depths in fields and comply with water holding requirements. Many growers requested, and were granted, emergency releases during this period (Fig. 6). Reclamation districts which had been designated as approved water management systems described in provision 1.a.2. in the molinate and thiobencarb programs had to discharge prematurely because of the burden of heavy rainfall and concomitant runoff.

The 1990 programs were implemented with the reasonable expection that performance goals would be attained. However, these weather-related factors combined to significantly affect the outcome of the 1990 programs and the molinate performance goal was exceeded.

1991 PROGRAM

PROGRAM DESCRIPTIONS

Molinate

The 1991 molinate program is designed to meet water quality objectives and the 1991 performance goal of 20 ppb molinate in Sacramento Valley surface waters. The program will be implemented using restricted material permits

conditioned to mitigate water quality problems associated with use. The conditions include:

1. All water treated with products containing molinate must be retained on the site of application for at least 24 days following application unless:

a. the treated water is contained within a tailwater recovery system, ponded on fallow land, or contained in other systems appropriate for preventing discharge. The system may discharge on the 25th day following the last application of molinate within the system.
    1. If the system is under the control of one permitee, treated water may be discharged from the application site in a manner consistent with product labeling.
    2. If the system is under the control of more than one permittee, treated water may be discharged from the application site 9 days following application.

b. the treated water is on acreage within the bounds of specific geographic areas that discharge negligible amounts of rice field drainage into the Sacramento River or its tributaries until fields are drained for harvest. All water on fields treated with molinate must be retained on the treated acreage until the ninth day following application.

2. Fields not specified in 1.a. and 1.b. may resume discharging field water on the 25th day following application at a volume not to exceed two inches of water over a drain box weir. Unregulated discharges from these fields may then resume after 7 days.

3. The County Agricultural Commissioner may authorize the emergency release of tailwater 7 days following application following a review of a written request which clearly demonstrates that the crop is suffering because of the water management requirements. Under an emergency release variance, tailwater may be released only to the extent necessary to mitigate the documented problem.

Thiobencarb

The 1991 thiobencarb program is designed to meet water quality objectives and the 1991 performance goal of 1.5 ppb thiobencarb in Central Valley surface waters. The program will be implemented using restricted material permits conditioned to mitigate water quality problems associated with use. The conditions include:

1. All water treated with products containing thiobencarb north of the line defined by Roads E10 and 116 in Yolo County and the American River in Sacramento County must be retained on the treated fields for at least 30 days following application unless:

a. the treated water is contained within a tailwater recovery system, ponded on fallow land, or contained in other systems appropriate for preventing discharge. The system may discharge 20 days following the last application of thiobencarb within the system.

1. If the system is under the control of one permitee, treated water may be discharged from the application site in a manner consistent with product labeling.
2. If the system is under the control of more than one permittee, treated water may be discharged from the application site 7 days following application.

b. the treated water is on acreage within the bounds of specific geographic areas that discharge negligible amounts of rice field drainage into the Sacramento River or its tributaries until fields are drained for harvest. All water on fields treated with thiobencarb must be retained on the treated acreage until the seventh day following application.

2. All water treated with products containing thiobencarb south of the line defined by Roads E10 and 116 in Yolo County and the American River in Sacramento County must be retained on the treated fields for at least 6 days following application.

Valent Chemical Company, distributor of products which contain thiobencarb, agreed to limit the distribution of thiobencarb for use on properties described in 1. above to 4.4 million pounds or enough to treat ~~110,000~~ acres. An additional 440,000 pounds may be used if, on May 1, 1991, flows in the Sacramento River at the "I" Street Bridge in Sacramento are forecast to exceed 15,000 cubic feet per second.

Carbofuran

The 1991 carbofuran program is designed to make progress toward the ~~1991~~ performance goal of 0.4 ppb in Central Valley surface waters. The program will be implemented using restricted material permits that are conditioned to mitigate water quality problems associated with use and possibly with amendments to product labeling. Provisions of this program include:

1. Pre-flood applications of carbofuran to rice fields must be incorporated into the soil.

2. Water shall not be discharged from fields treated with carbofuran for at least 24 days following initial flooding (pre-flood application) or following application (post-plant application) unless:

a. the treated water is contained within a tailwater recovery system, ponded on fallow land, or contained in other systems appropriate for preventing discharge. The system may discharge on the 25th day following the last application of carbofuran within the system.
    1. If the system is under the control of one permitee, treated water may be discharged from the application site in a manner consistent with product labeling.
    2. If the system is under the control of more than one permittee, treated water may be discharged from the application site 9 days following application.

b. the treated water is on acreage within the bounds of specific geographic areas that discharge negligible amounts of rice field drainage into the Sacramento River or its tributaries until fields are

drained for harvest. All water on fields treated with carbofuran must be retained on the treated acreage until the ninth day following application.

3. The County Agricultural Commissioner may authorize the emergency release of tailwater 7 days following application following a review of a written request which clearly demonstrates that the crop is suffering because of the water management requirements. Under an emergency release variance, tailwater may be released only to the extent necessary to mitigate the documented problem.

Methyl parathion

The 1991 methyl parathion program is designed to meet water quality objectives and the 1991 performance goal of 0.26 ppb methyl parathion in Sacramento Valley surface waters. The program will be implemented using restricted material permits that are conditioned to mitigate water quality problems associated with use. The conditions include:

1. Water shall not be discharged from fields treated with methyl parathion until the 25th day following application unless:

a. the treated water is contained within a tailwater recovery system, ponded on fallow land, or contained in other systems appropriate for preventing discharge. The system may discharge on the 25th day following the last application of molinate within the system. Treated water may be discharged from the application site in a manner consistent with product labeling.

b. the treated water is on acreage within the bounds of specific geographic areas that discharge negligible amounts of rice field drainage into the Sacramento River or its tributaries until fields are drained for harvest. All water on fields treated with molinate must be retained on the treated acreage until the ninth day following application.

2. The County Agricultural Commissioner may authorize the emergency release of tailwater 7 days following application following a review of a written request which clearly demonstrates that the crop is suffering because of the water management requirements. Under an emergency release variance, tailwater may be released only to the extent necessary to mitigate the documented problem.

Discussion

Molinate

The 1991 molinate program relies upon the basic strategy used since 1984, that mandatory water holding periods following application will be used to allow molinate to dissipate before field water is discharged. Since the dissipation half-life of molinate is usually between three and four days, increasing the holding period can significantly affect molinate discharges and concentrations in receiving waters.

This will be the second successive year in which the molinate holding time was increased by five days. The 1990 program was offered with the

expectation that this increase would result in compliance with the 1990 performance goal. However, unusually cold and wet weather apparently negated the benefits of the additional dissipation period and the performance goal was not met.

The 1991 program includes a basic holding time ten days longer than the 14 day holding period used in 1989. Since the peak molinate concentration detected in the agricultural drains was 60 ppb in 1989, the additional dissipation time provided in the 1991 program should reduce this concentration in all but unusual circumstances by 75%; adequate to attain the performance goal of 20 ppb.

The increased holding time also affects those who have approved water management systems. In 1990, the program allowed multi-grower systems to discharge earlier than single grower systems. The current program requires that treated water within all approved systems be held within the system for at least 24 days following the last application within the system.

The program also includes a provision which allows molinate users to discharge treated water before the end of the 24 day post-application holding period with the approval of the county agricultural commissioner. Requests for such discharges must include a inspection report by a licensed pest control advisor, demonstrating that the rice crop is threatened by problems aggravated by the long holding requirement. Only enough water may be discharged to ameliorate the problem.

With increased holding time requirements, there may be an increase in the occurrence of agronomic problems and thus with the number of requests for early release. However, there is no evidence which suggests that this provision has been abused in previous years (Figure 6) or that abuse will undermine efforts to meet performance goals.

Thiobencarb

The thiobencarb program also retains the basic structure of the 1990 program. Strict water management requirements and a sales limit in the Sacramento Valley of 4.4 million pounds of formulated product will continue to keep thiobencarb concentrations in the surface waters very low and below the 1991 performance goal of 1.5 ppb.

The water management requirements for thiobencarb users are basically the same as those used in 1990. The current program requires that treated water within approved water management systems that involve a single grower be held within the system for at least 19 days following the last application within the system. However, the program allows multi-grower systems to discharge earlier than single grower systems. The proposed program requires that treated water within all approved systems be held within the system for at least 19 days following the last application within the system.

Carbofuran

Although carbofuran can legally be applied to alfalfa, grapes, sugarbeets and other commodities, use in rice to control rice water weevil has been identified as the major source of carbofuran contamination in state waterways. During the period in which carbofuran is detected in the Colusa

Basin Drain, carbofuran is only applied to rice and sugarbeets. The contribution of sugarbeets to the carbofuran load in the drain is minimal (see enclosed report entitled, "Off-Field Movement and Dissipation of Soil-Incorporated Carbofuran from Three Commercial Rice Fields and Potential Discharge in Agricultural Runoff Water").

Currently, users of carbofuran in rice are not subject to any special program addressing water quality. Users typically apply carbofuran granules prior to flooding and incorporate the material in the two uppermost paddies, a practice required to protect foraging waterfowl. Fields are then flooded and seeded. During the period preceeding the application of molinate or thiobencarb, excess field water is discharged. Water discharged at this time, usually within a week after planting, contains carbofuran which may not have had sufficient time to dissipate. In 1990, and in all but one year in which carbofuran was monitored in state waterways, peak concentrations were detected during this period; late April and early May.

Rice growers discharge water at this time in order to establish the water depths needed to optimize seedling growth. In most conditions, rice seedlings must emerge from field water at the third or fourth leaf stage. Water that is too deep, approximately eight inches or more, may kill the seedling at this stage. Deep water can be particularly troublesome in the bottom-most paddie, where any excess water that was delivered to the field accumulates. Any leakage through levees or rice boxes will also flow downgradient toward the bottom-most paddie. Growers respond by discharging water any time after the field is flooded but before molinate or thiobencarb is applied and water management options become limited.

Growers that use the "Leathers Method" drain the entire rice field during the first week following seeding. With this method, the drained field provides an environment which promotes rooting into mud. This practice is more common in areas with soils which become silty when flooded, making it difficult for seedlings to anchor themselves. Poorly anchored seedlings are easily uprooted when winds create turbulence within the field water. Draining fields in this way also results in the discharge of relatively high volumes of carbofuran-laden water. Fields are reflooded prior to molinate or thiobencarb applications.

The proposed program described above is offered as a means to attain the 1991 performance goal for carbofuran of 0.4 ppb. While significant reductions in carbofuran discharges are expected, it is difficult to quantify those reductions and determine whether the performance goal will be met. In fact, it is not possible to quantify the reductions of carbofuran concentrations in state waterways, regardless of the use modifications required of users. However, the program includes two strong components which should reduce carbofuran discharges from treated rice fields; total field incorporation and a long holding period for dissipation.

FMC Corporation, the manufacturer of products containing carbofuran (ie. Furadan), has applied for a label amendment which requires that all preflood applications of carbofuran be followed by incorporation. Previously, only the uppermost two checks in the rice fields had to be incorporated in order to protect foraging waterfowl. In the event that the label amendment

cannot be approved by the April application period, the incorporation requirement will be implemented by permit condition. This practice should reduce carbofuran discharges. The enclosed report discusses the evidence for using incorporation as a means to achieve these reductions.

This program also relies on water in fields treated with carbofuran prior to flooding from being discharged into state waterways from flooding through the end of the molinate holding time. In most cases, this provides a carbofuran dissipation period of at least one month. This provision will greatly limit, if not eliminate, pre-flood applications to fields that are managed under the Leathers Method. This may significantly reduce carbofuran discharges, given that in the past, large volumes of carbofuran-laden water were discharged from these fields. Carbofuran users who use this method may aerially apply the material shortly before reflood. Another alternative is to monitor adult weevil feeding damage and when necessary, drain, treat, and reflood to prevent larval damage.

An emergency release provision, similar to that available to molinate users, will be available to carbofuran users.

Methyl Parathion

Methyl parathion is used to control tadpole shrimp in rice fields, usually during the first week following seeding and before molinate and thiobencarb are applied. The peak concentrations of methyl parathion occur in state waterways, principally in the Colusa Basin Drain, during this period. Presumably, treated water is discharged from application sites after the three day holding period specified on product labeling, carrying methyl parathion in it. Methyl parathion concentrations in late May and early June are below 1991 performance goals, indicating that the molinate and thiobencarb holding periods are long enough to provide satisfactory dissipation of methyl parathion as well.

This program, like the carbofuran program will require that field water be held on the site of application or within approved water management systems until the end of the molinate or thiobencarb holding time. This dissipation period will provide for the dissipation necessary to meet the 1991 performance goals for methyl parathion.

The methyl parathion program includes a provision allowing emergency releases of field water that has been treated with methyl parathion in order to prevent crop damage.

This program will probably result in an increase in the use of copper sulfate. This compound also controls tadpole shrimp and growers who use it may preserve flexibility in their water management options. Alternatively, growers using the Leathers Method may not require chemical control of tadpole shrimp prior to herbicide applications as draining field water may kill the shrimp.

Malathion

Monitoring of Sacramento Valley waterways indicate that malathion has been present in agricultural drains in May and June at concentrations which exceeded 1991 performance goal of 0.1 ppb. The manufacturers of malathion

contracted with a local consultant to identify sources, so that mitigation measures could follow.

A report has not been prepared by the consultant yet, but preliminary information can provide the basis for a mitigation program. The consultant collected pesticide use report data which identify malathion applications during the week preceeding the detections of malathion in the agricultural drains. Use on rice was identified as the only use that could result in this contamination.

Malathion is labeled for use on rice to control rice leafminer when rice seedlings are emerging from the water. Applications would therefore occur early in the growing season. Since opportunities for discharging rice field water during the first month of the growing season will be greatly reduced in 1991, malathion discharges should be reduced to the point where concentrations in the agricultural drains will not exceed performance goals.

Other Considerations

Practices used during the application of these pesticides may also affect concentrations in the agricultural drains and the Sacramento River. County agricultural commissioners will be instructed to be diligent when observing applications to insure that instructions on product labeling are followed. This will prevent accidental applications to drains and insure that label rates are not exceeded near wier boxes within the field. In addition, the department plans to research the contribution of aerial drift to the methyl parathion load in agricultural drains adjacent to rice fields.

Table 1. Acres treated with Ordram® (molinate) and Bolero® (thiobencarb) in the counties of the Sacramento Valley in 1990.

County	Acres treated	
	Ordram	Bolero
Butte	83,284	3,313
Colusa	91,789	6,925
Glenn	67,098	1,780
Placer	12,406	405
Sacramento	10,413	698
Sutter	67,154	2,570
Tehama	735	0
Yolo	10,185	7,912
Yuba	27,198	0
Total	370,261	23,603

Values are based on Notices-of-Application submitted to county agricultural commissioners.

Table 2. Number of acres in the Sacramento Valley treated with Ordram® (molinate) from which water was discharged prior to the end of the minimum post-application holding period from 1987 through 1990 with the approval of the County Agricultural Commissioners.

	Acres released		
	Year	Ordram	% of total acres treated
	1987	5,712	1.94
	1988	4,897	1.41
	1989	3,235	0.86
	1990	23,394	6.32
Total		37,238	2.68

Table 3: Participation in a cost-sharing program for designing and installing tailwater recovery systems in rice-growing regions, sponsored by the federal Agricultural Stabilization and Conservation Service (August 1986 to September 1990.)

County	Number of participants[1]	Federal funds (dollars) spent
Butte	26	136,860
Colusa	51	221,738
Glenn	25	191,829
Placer	10	50,438
Sutter	26	108,000
Yolo	16	121,156
Yuba	6	71,106
Total	160	901,127

1. Includes participants in pooled agreements.

1987 figures not exact due to many projects that were not fully initiated. Sutter and Yolo Counties included large pooling agreements.

Table 4. Concentrations of Ordram® (molinate) detected at seven monitoring sites sampled in 1990.[1]

Date	Concentration (µg/L)						
	CBD1	CBD5	SS1	BS1	SRRUN4	SR1	SR2[2]
4/30	<1.0	2	<1.0	<1.0	[3]	<1.0	<1.0
5/7	<1.0	8	<1.0	3		<1.0	<1.0
5/14	7	20	4.4	12		<1.0	<1.0
5/21	20	17	11	18		1.3	1.3
5/24	16	22	12	14	3.7	2.5	2
5/28	24	24		23		5	3.4
5/31	35	59	30	36	8	8.2	6.2
6/4	51	48	40	33	5	8.9	8.5
6/7	50	46	37	31	4.4	5.1	3.4
6/11	50	17	20	29	3.2	3.4	2.9
6/14	32	14	18	19	1.5	2.1	1.1
6/18	19	13	16	14		1.7	<1.0
6/25	10.1	8.5	10.2	8.8		2.2	
7/2	6.1	5.1	2.1	6.2		<1.0	<1.0

1. Samples collected by the California Department of Fish and Game and analyzed by ICI Americas, Inc.

2. CBD1 Colusa Basin Drain at Roads 109 and 99E near Knight's Landing in Yolo County.
   CBD5 Colusa Basin Drain at Highway 20 in Colusa County.
   SS1 Sacramento Slough at DWR gauge station in Sutter County.
   BS1 Butte Slough at Highway 20 in Sutter County.
   SRRUN4 Sacramento River, 3 km downstream from confluence with Colusa Basin Drain.
   SR1 Sacramento River at Village Marina in Sacramento County.
   SR2 Sacramento River at Freeport Bridge in Sacramento County.

3. Blanks in table indicate that no samples were taken.

Table 5. Concentrations of Ordram® (molinate) and Bolero® (thiobencarb) in the Sacramento River at the intake to the City of Sacramento water treatment facility in 1990.

	Concentration (µg/L)			Concentration (µg/L)	
Date	molinate	thiobencarb	Date	molinate	thiobencarb
4/18	<0.10	<0.10	5/31	4.9	0.18
4/26	<0.10	<0.10	6/1	5.1	0.17
4/30	<0.10	<0.10	6/2	4.1	<0.10
5/2	<0.10	<0.10	6/3	3.9	<0.10
5/4	<0.10	<0.10	6/4	6.5	<0.10
5/7	<0.10	<0.10	6/5	3.3	<0.10
5/9	0.11	<0.10	6/6	2.2	<0.10
5/11	<0.10	<0.10	6/7	2.3	<0.10
5/14	0.27	<0.10	6/8	3.5	<0.10
5/16	0.52	<0.10	6/9	3.0	<0.10
5/18	0.44	<0.10	6/10	1.2	<0.10
5/21	0.65	<0.10	6/11	1.2	<0.10
5/22	0.96	<0.10	6/12	0.97	<0.10
5/23	1.2	<0.10	6/13	0.92	<0.10
5/24	2.1	<0.10	6/15	1.1	0.13
5/25	3.3	<0.10	6/18	0.65	<0.10
5/26	3.0	<0.10	6/20	1.2	<0.10
5/27	2.2	<0.10	6/22	0.88	<0.10
5/28	2.3	<0.10	6/25	0.53	<0.10
5/29	5.6	0.11	8/28	<0.10	<0.10
5/30	5.1	0.52	9/6	<0.10	<0.10

Samples collected and analyzed by the City of Sacramento.

Table 6. Concentrations of thiobencarb (Bolero®) detected at seven monitoring sites sampled in 1990.[1]

	Concentration (ug/L)						
Date	CBD1	CBD5	SS1	BS1	SRRUN4	SR1	SR2[2]
4/30	<1.0	<1.0	<1.0	<1.0	[3]	<1.0	<1.0
5/7	<1.0	<1.0	<1.0	<1.0		<1.0	<1.0
5/14	<1.0	<1.0	<1.0	<1.0		<1.0	<1.0
5/21	<1.0	<1.0	<1.0	<1.0		<1.0	<1.0
5/24	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
5/28	<1.0	<1.0		2.0		<1.0	<1.0
5/31	<1.0	<1.0	<1.0	1.4	<1.0	<1.0	<1.0
6/4	<1.0	1.3	<1.0	<1.0	<1.0	<1.0	<1.0
6/7	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
6/11	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
6/14	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
6/18	<1.0	<1.0	<1.0	<1.0		<1.0	<1.0
6/25	<1.0	<1.0	<1.0	<1.0		<1.0	
7/2	<1.0	<1.0	<1.0	<1.0		<1.0	<1.0

1. Samples collected by the California Department of Fish and Game and analyzed by ICI Americas, Inc.

2. CBD1 Colusa Basin Drain at Roads 109 and 99E near Knight's Landing in Yolo County.
   CBD5 Colusa Basin Drain at Highway 20 in Colusa County.
   SS1 Sacramento Slough at DWR gauge station in Sutter County.
   BS1 Butte Slough at Highway 20 in Sutter County.
   SRRUN4 Sacramento River, 3 km downstream from confluence with Colusa Basin Drain.
   SR1 Sacramento River at Village Marina in Sacramento County.
   SR2 Sacramento River at Freeport Bridge in Sacramento County.

3. Blanks in table indicate that data were unavailable.

Table 7. Concentrations of Londax® (bensulfuron methyl) detected at three monitoring sites[1] sampled in 1990.[2]

	Concentration (ug/L)		
Date	CBD1	SS1	SR1
5/21	0.560	<0.5	<0.5
5/24	0.520	<0.5	<0.5
5/28	1.14	[3]	<0.5
5/31	1.52	0.74	<0.5
6/4	2.08	1.40	<0.5
6/7	2.10	1.40	<0.5
6/11	1.66	<0.5	<0.5
6/14	1.28	<0.5	<0.5
6/18	0.76	<0.5	<0.5
6/21	0.700	0.54	<0.5

1. CBD1 Colusa Basin Drain at Roads 109 and 99E near Knight's Landing in Yolo County.
   SS1 Sacramento Slough at DWR gauge station in Sutter County.
   SR1 Sacramento River at Village Marina in Sacramento County.

2. Samples collected by the California Department of Fish and Game and analyzed by Morse Laboratories through Du Pont.

3. No data available.

Table 8. Concentrations of carbofuran (Furadan®) detected at four monitoring sites[1] sampled in 1990.[2]

Date	Concentration (ug/L) CBD1	CBD5	SS1	SR1
4/16	ND[3]	ND	ND	0.6[4]
4/19	ND	1.3, 1.5[5]	ND	ND
4/23	0.9, 0.6	2.1	ND	ND
4/26	ND	2.3	ND	[6]
4/30	1.0	2.6	ND	ND, ND
5/3	0.9, 1.3	1.7	ND, ND	ND
5/7	ND	1.2	ND	ND
5/10	ND, 0.6	1.7, 1.2	ND	ND
5/14		1.0	ND	ND, ND
5/17	ND	ND	ND	ND
5/21	0.7, 0.9	ND, ND	ND	ND
5/24	0.8, 0.6	ND	0.8	ND
5/28	ND, 0.6	ND		ND
5/31	0.6, ND	0.8	0.8, 0.9	ND
6/4	ND	ND	0.8	ND
6/7	ND, ND	1.0, 0.9	0.6	ND
6/11	ND, ND	0.6	ND	ND
6/14	ND	ND	ND	ND
6/18	ND	ND, ND	ND, ND	ND
6/21	ND	ND	ND, ND	ND
6/25	ND	ND	ND	ND, ND
6/28	ND	ND	ND	ND

1. CBD1 Colusa Basin Drain at Roads 109 and 99E near Knight's Landing in Yolo County.
   CBD5 Colusa Basin Drain at Highway 20 in Colusa County.
   SS1 Sacramento Slough at DWR gauge station in Sutter County.
   SR1 Sacramento River at Village Marina in Sacramento County.

2. Samples collected by the California Department of Fish and Game and analyzed by FMC Corporation.

3. ND = None detected at a minimum detection limit of 0.5 ug/L.

4. FMC reports the minimum quantitation limit is 1.6 ug/L, thus each result at or below that level is an estimate greater than the minimum detection level.

5. Results separated by commas are replicate analyses.

6. Blanks in table indicate samples were not available for analysis.

Table 9. Concentrations of malathion (M) and methyl parathion (MP) in the Sacramento Valley at three sampling sites.

Date[3]	Chemical concentrations (ug/L)[1] CBD1[2] M	CBD1 MP	SS1 M	SS1 MP	SR4 M	SR4 MP
4/11	ND[4]	ND	--	--	ND	ND
4/16	ND	ND	ND	ND	ND	ND
4/19	ND	ND	--	--	ND	ND
4/21	ND	ND	--	--	ND	ND
4/23	ND	ND	ND	ND	ND	ND
4/26	ND	ND	--	--	ND	ND
4/28	ND	ND	--	--	ND	ND
4/30	ND	ND	ND	ND	ND	ND
5/3	ND	ND	--	--	ND	ND
5/5	ND	ND	--	--	ND	ND
5/7	--	--	ND	ND	--	--
5/8	ND	ND	--	--	ND	ND
5/10	--	--	ND	ND	--	--
5/12	ND	0.41	--	--	ND	ND
5/14	ND	0.61	ND	ND	ND	ND
5/17	ND	0.66	ND	ND	ND	ND
5/19	ND	0.42	--	--	ND	ND
5/21	ND	0.54	ND	ND	ND	ND
5/24	0.59	0.22	ND	ND	ND	ND
5/26	ND	0.21	--	--	ND	ND
5/28	ND	0.21	--	--	ND	ND
5/30	ND	0.12	--	--	ND	ND
5/31	--	--	ND	ND	--	--
6/2	0.12	0.20	--	--	ND	ND
6/4	0.15	0.12	ND	0.10	ND	ND
6/7	ND	0.18	ND	ND	ND	ND
6/9	ND	ND	--	--	ND	ND
6/11	ND	0.13	ND	ND	ND	ND
6/13	ND	ND	--	--	ND	ND
6/14	--	--	ND	ND	--	--
6/16	ND	ND	--	--	ND	ND
6/18	ND	ND	ND	ND	ND	ND
6/21	ND	ND	ND	ND	ND	ND
6/23	ND	ND	--	--	ND	ND
6/25	ND	ND	ND	ND	ND	ND

1. M Malathion.
   MP Methyl parathion.

2. CBD1 Colusa Basin Drain at Roads 109 and 99E near Knight's Landing in Yolo County.
   SS1 Sacramento Slough at DWR gauge station in Sutter County.
   SR4 Sacramento River at Rio Vista in Sacramento County.

3. Grab samples collected from 4/11 to 5/8 and 48-hour composite samples collected from 5/12 to 6/25.

4. ND Not detected at concentrations $\geq$1 ug/L.
   -- Not sampled.

Table 10. Estimated mass transport of Ordram® (molinate) and Bolero® (thiobencarb) in the Sacramento River past Sacramento in the years 1982-1990.

Year	Kg (pounds) Transported			
	molinate		thiobencarb	
1982	18,464.9	(40,666.9)	[1]	
1983[2]	2,752.9	(6,056.5)	623.7	(1,372.2)
1984	7,352.0	(16,174.4)	715.2	(1,573.5)
1985	6,014.8	(13,232.5)	2,317.5	(5,098.6)
1986	4,622.1	(10,168.7)	845.7	(1,860.6)
1987	2,342.3	(5,153.2)	22.8	(50.2)
1988	3,194.2	(7,027.2)	68.1	(149.8)
1989	2,003.8	(4,408.4)	11.4	(25.2)
1990	2,858.0	(6,287.6)	51.4	(113.1

1. Mass transport was not calculated due to incomplete monitoring data.

2. The Colusa Basin Drain, a major agricultural drain, did not contribute to the mass transport at Sacramento because the drain was routed into the Yolo Bypass during unusually high Sacramento River flows.

Figure 1. Peak molinate (Ordram®) concentrations in the Colusa Basin Drain at Knight's Landing in 1981 - 1990 and performance goals for molinate in 1990 - 1992.

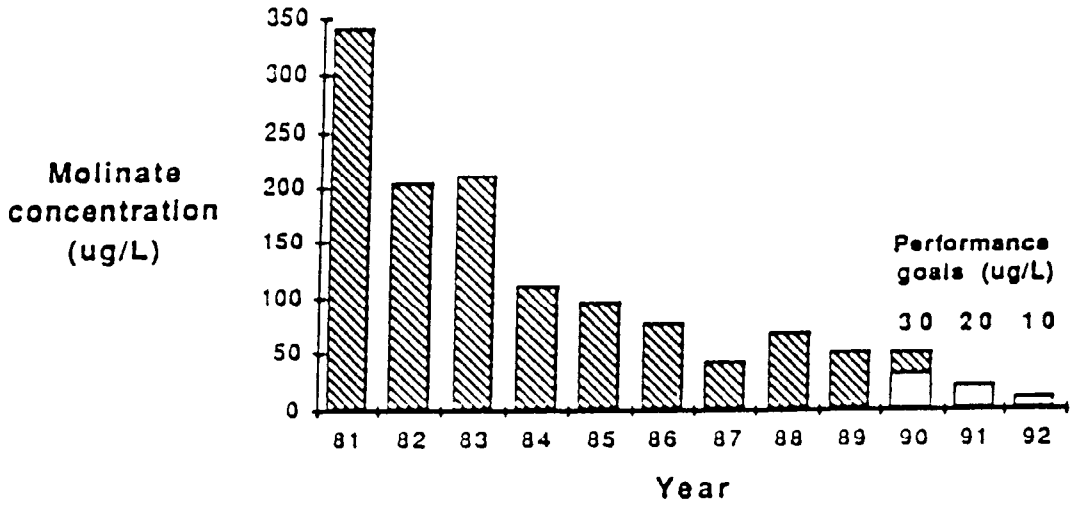
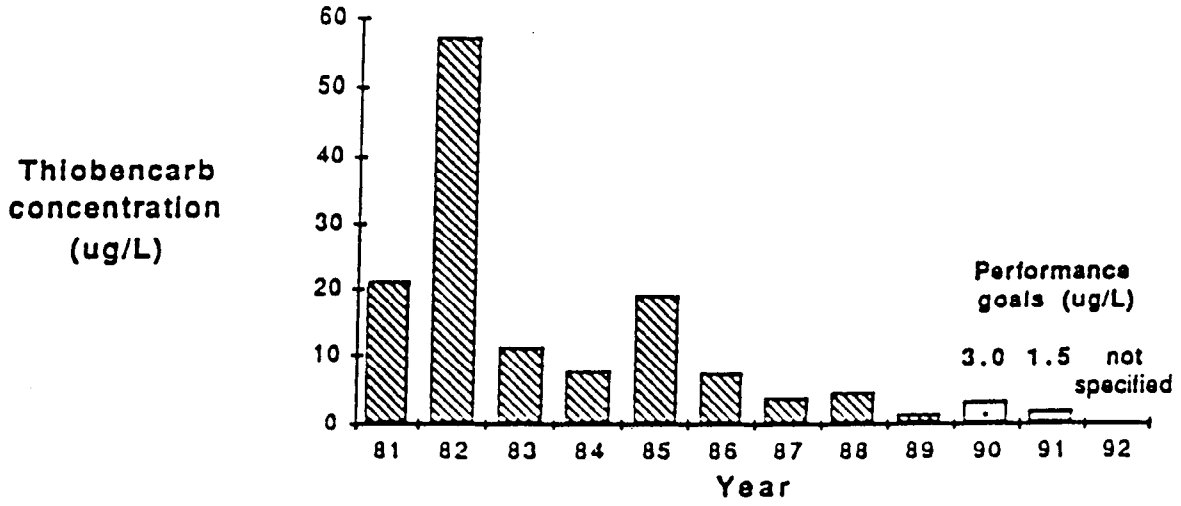


Figure 2. Peak thiobencarb (Bolero®) concentrations in the Colusa Basin Drain at Knight's Landing in 1981 - 1990 and performance goals for thiobencarb in 1990 - 1992.



* Thiobencarb levels at this site were below detection (<1.0 ug/l). The maximum level in the Sacramento Valley in 1990 was 2.0 ug/l in Butte Slough in Sutter County.

Figure 3. Peak carbofuran (Furadan®) concentrations in the Colusa Basin Drain at Knight's Landing in 1987 - 1990 and performance goals for carbofuran in 1991 - 1992.

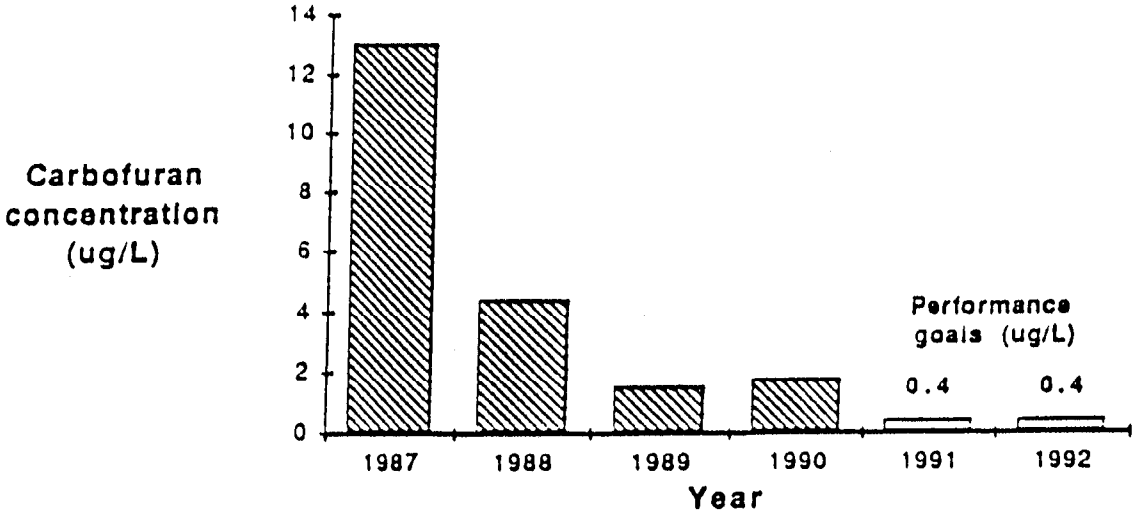


Figure 4. Peak methyl parathion concentrations in the Colusa Basin Drain at Knight's Landing in 1989 - 1990 and performance goals for methyl parathion in 1991 - 1992.

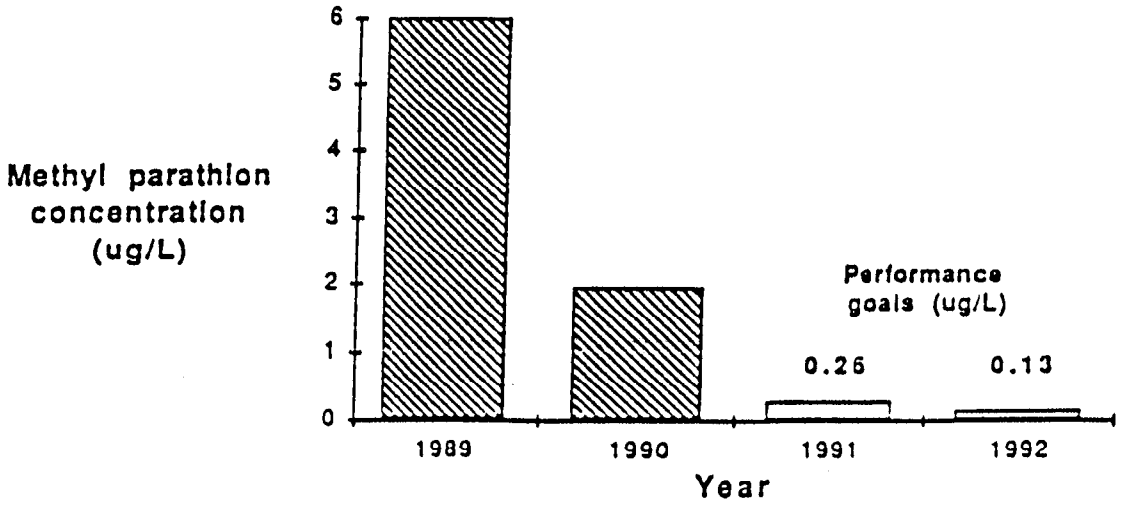


Figure 5. Acres treated with molinate (open bars) and thiobencarb (filled bars) in the Sacramento Valley in 1990 , the deviation of maximum daily temperatures from the 30 year maximum temperatures, and rain in excess of 0.25 inches (arrows).

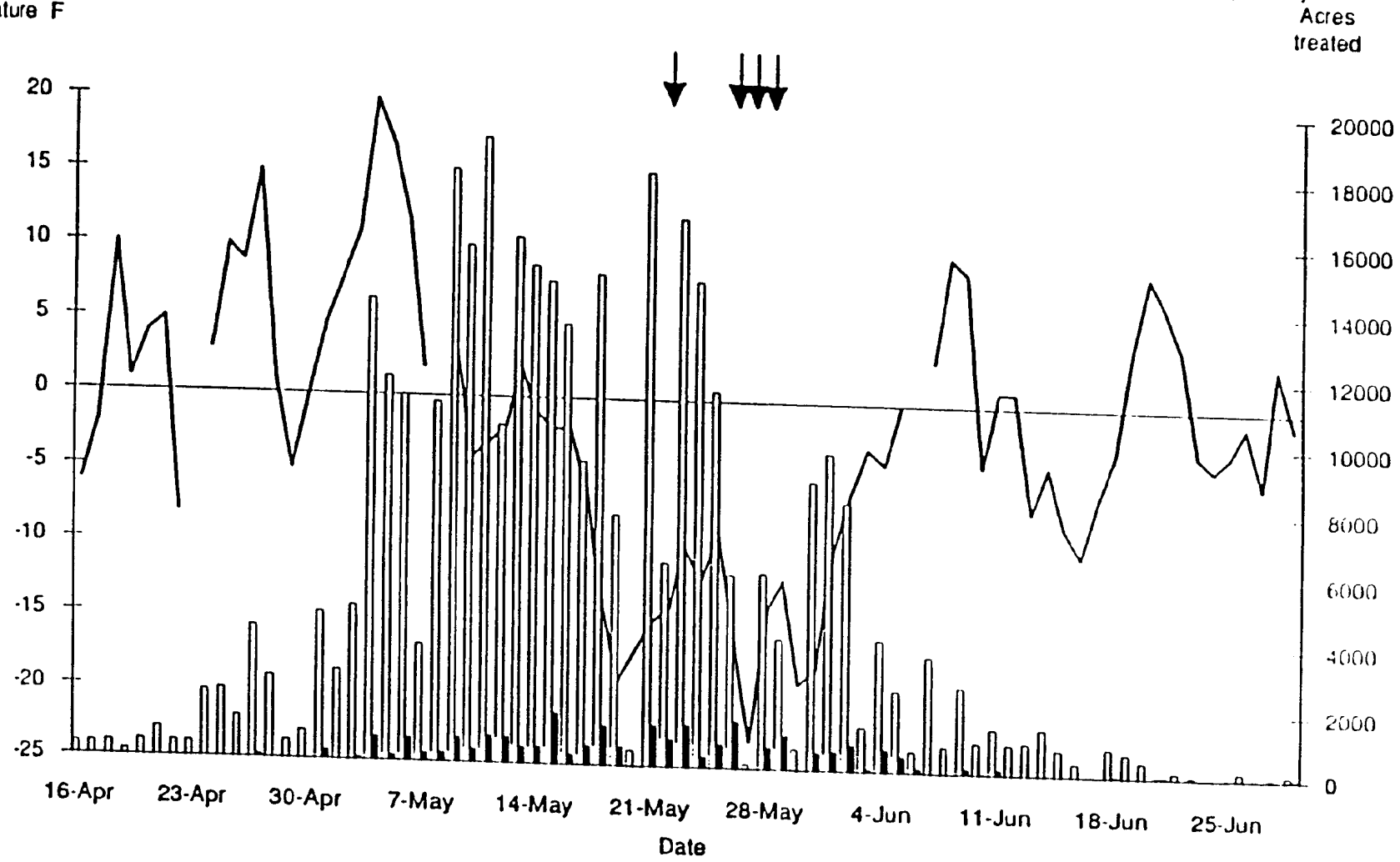


Figure 6. Emergency releases of water (by date in 1990) from molinate-treated acreages in the Sacramento Valley prior to completion of the post-application holding period (with County Commissioner approval). Arrows denote rainfall events in excess of 0.25 inches measured at Colusa.